PRIORITIZATION OF CONSERVATION AREAS USING SPECIES DISTRIBUTION MODELING BASED ON CURRENT DATA OF BUTTERFLIES IN JOHOR

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Verily, with every hardship comes ease. (94:6)

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ABSTRACT

Rapid disappearance of habitats and species justifies the need to study species range and distributions so that high-priority conservation areas can be identified. Species distribution modeling (SDM) is an approach that can overcome the time and budget constraints of protected area management. This research aims at providing an efficient method for stakeholders to develop conservation strategies using butterflies as environmental surrogates. The objectives are to (i) document butterfly diversity in Johor, (ii) map out their distribution using geographic information system (GIS), (iii) determine the best model with variables that affects the distribution of butterflies in Johor, (iv) predict the distribution in less sampled areas using SDM, and (v) determine strategies for prioritization of conservation areas based on the results obtained from objective (iv). Butterfly presence data were obtained from field samplings from ten sites throughout Johor, published literature, reports, and reference collections. A total of 2347 presence records comprising of 447 species were collated in Johor. This accounts for 42% of the overall diversity in Peninsular Malaysia. MaxEnt was then used to model and map the potential distribution of butterflies based on land cover, vegetation indices, land use, elevation, and bioclimatic layers as variables. Nine models were formulated and compared based on the area under curve (AUC) for receiver operating characteristic (ROC) values, percentage of habitat suitability, and variable complexity. Model 6 was chosen as the best model with distance to forest, temperature, precipitation, and distance to road being the highest contributing variables. Forest-dwelling butterflies consistently showed the best model performance. Based on the habitat suitability map generated, the high to low priority ranking of conservation clusters are as follows: Endau–Rompin–Labis forest complex, Gunung Ledang forest complex, Pulai forest complex, Kluang forest reserve, and Maokil–Air Hitam–Bukit Inas forest complex. Implementation of MaxEnt in Malaysia can be improved through capacity building, fostering better communication between stakeholders and integration into site-based management plans.

ABSTRAK

Kelenyapan habitat dan spesis yang pantas menjustifikasikan kepentingan mengkaji julat dan taburan spesis supaya kawasan pemuliharaan berkepentingan tinggi dapat dikenal pasti. Pemodelan taburan spesis (SDM) mampu mengatasi kekangan masa dan kewangan dalam pengurusan kawasan perlindungan. Kajian ini menyediakan kaedah yang cekap bagi membangunkan strategi pemuliharaan menggunakan kupu-kupu sebagai surogat persekitaran. Objektif kajian ialah (i) merekodkan kepelbagaian kupu-kupu di Johor, (ii) memeta taburan kupu-kupu menggunakan sistem maklumat geografi (GIS), (iii) menentukan model terbaik dengan pemboleh ubah yang menentukan taburan kupu-kupu di Johor, (iv) meramal taburan kupu-kupu di kawasan yang kurang disampel menggunakan SDM, dan (v) menentukan strategi mengutamakan kawasan pemuliharaan berdasarkan hasil dapatan daripada objektif (iv). Data kehadiran kupu-kupu diperoleh daripada kerja lapangan di 10 kawasan sekitar Johor, karya ilmiah, laporan, dan koleksi rujukan. Sebanyak 2347 rekod kehadiran 447 spesies telah dikumpulkan di Johor. Ini merangkumi 42% daripada kepelbagaian kupu-kupu di Semenanjung Malaysia. Taburan kupu-kupu dimodelkan menggunakan MaxEnt dengan pembolehubah seperti litupan tanah, indeks tumbuhan, guna tanah, ketinggian, dan lapisan bioiklim. Sembilan model dibandingkan berdasarkan nilai ukur luas lengkung (AUC) ciri kendalian penerima (ROC), peratusan kesesuaian habitat, dan kerumitan pembolehubah. Model 6 ialah model terbaik dengan sumbangan terbanyak daripada pembolehubah jarak dari hutan, suhu, titisan, dan jarak dari jalan. Kupu-kupu hutan menunjukkan prestasi model yang terbaik dan konsisten. Berdasarkan janaan peta kesesuaian habitat, susunan kelompok pemuliharaan berkepentingan tinggi adalah seperti berikut: kompleks hutan Endau–Rompin–Labis, kompleks hutan Gunung Ledang, kompleks hutan Pulai, Hutan Simpan Kluang, dan kompleks hutan Maokil–Air Hitam–Bukit Inas. Penggunaan MaxEnt di Malaysia boleh dipertingkatkan dengan pembinaan kapasiti, komunikasi berkesan antara pemegang taruh, dan intergrasi ke dalam pelan perancangan setempat.

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LIST OF SYMBOLS AND ABBREVIATIONS

H'	-	Shannon Index of Diversity
p_i	-	Proportion of individuals in a species
s	-	Number of species
E_H	-	Evenness Index
J	-	Jaccard Similarity Index
C	-	Number of overlapping species
$Pr(x)$	-	Probability of x
z	-	Vector of environmental variables
r	-	Pearson correlation coefficient
1MBEON	-	1Malaysia Biodiversity Enforcement Operation Network
a.s.l	-	Above sea level
AAGR	-	Annual Average Growth Rate
AMNH	-	American Museum of Natural History
ATM	-	Angkatan Tentera Malaysia (Malaysian Armed Forces)
AUC	-	Area Under Curve
BRT	-	Boosted Regression Tree
BS	-	Bukit Soga
CBD	-	Convention on Biological Diversity
CFS	-	Central Forest Spine
CFSMP	-	Central Forest Spine Master Plan
CIS-UKM	-	Center for Insect Systematics Universiti Kebangsaan Malaysia
DEM	-	Digital Elevation Model
DWNP	-	Department of Wildlife and National Parks
ENFA	-	Ecological Niche Factor Analysis

ENM	-	Environmental Niche Model
EPU	-	Economic Planning Unit
ESA	-	Endangered Species Act
EVI	-	Enhanced Vegetation Index
FAO	-	Food and Agriculture Organizations of the United Nations
FRIM	-	Forest Research Institute of Malaysia
GA	-	Gunung Arong
GAM	-	Generalized Additive Models
GB	-	Gunung Belumut
GBIF	-	Global Biodiversity Information Facility
GDP	-	Gross Domestic Product
GEF	-	Global Environment Facility
GIS	-	Geographic Information System
GL	-	Gunung Ledang
GLM	-	Generalized Linear Models
IBS	-	Industrialized Building System
IC-CFS	-	Improving Connectivity in the Central Forest Spine
JB	-	Gunung Janing Barat
JNPC	-	Johor National Parks Corporation
JPNJ	-	Johor State Forestry Department
JPSM	-	Peninsular Malaysia Forestry Department
KATS	-	Ministry of Water, Land and Natural Resources
LSA	-	Landscape Species Approach
MESTECC	-	Ministry of Energy, Science, Technology, Environment and Climate Change
METT	-	Management Effectiveness Tracking Tool
MNS	-	Malaysian Nature Society
MODIS	-	Moderate Resolution Imaging Spectroradiometer
NASA	-	National Aeronautics and Space Administration
NDVI	-	Normalized Difference Vegetation Index
NEP	-	National Environment Policy
NFA	-	National Forestry Act
NFP	-	National Forestry Policy

NGO	-	Non-Government Organizations
NIPAP	-	National Integrated Protected Areas Programme
NOAA	-	National Oceanic Atmospheric Administration
NPBD	-	National Policy on Biological Diversity
NRE	-	Ministry of Natural Resource and Environment
OLI	-	Operational Land Imager
PA	-	Protected Area
PAST	-	Paleontological Statistics software
PFR	-	Permanent Forest Reserve
PL	-	Gunung Pulai
PL	-	Primary Linkages for Central Forest Spine
PLANMalaysia	-	Federal Department of Town and Country Planning
PPPs	-	Policies, plans and programs
PT	-	Gunung Panti
REDD	-	UN Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
ROC	-	Receiver Operating Characteristics
RS	-	Remote Sensing
RSNJ	-	Johor Structural Development Plan
SB	-	Sungai Bantang
SDM	-	Species Distribution Modelling
SL	-	Secondary Linkages for Central Forest Spine
SRTM	-	Shuttle Radar Topography Mission
TIRS	-	Thermal Infrared Sensor
TM	-	Taka Melor
TNJER	-	Taman Negara Johor Endau Rompin
UG	-	Upeh Guling Waterfall
UN	-	United Nations
UNDP	-	United Nations Development Programme
UNEP	-	United Nations Environment Programme
UNFCCC	-	United Nations Framework Convention on Climate Change
USGS	-	United States Geological Survey

WCS	-	Wildlife Conservation Society
WINGS	-	Winning Investigative Network for Great Science
WWF	-	World Wildlife Fund for Nature

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LIST OF PUBLICATIONS

(i) **Aqilah Awg Abdul Rahman**, Maryati Mohamed, Norradihah Ismail, Noor Izwan Anas (2018). "A Review of Distribution and Diversity of Butterfly (Lepidoptera: Rhopalocera) Fauna in Johor, Malaysia." Serangga. Vol 23, No. 1, pp. 12 – 23 **(ISI Web of Science)**

(ii) **Aqilah Awg Abdul Rahman**, Maryati Mohamed, Alona Cuevas Linatoc (2018). "Butterfly (Lepidoptera: Rhopalocera) diversity in Bukit Soga, the green lung of Batu Pahat, Malaysia" AIP Conference Proceedings Vol 2002, No. 020005 (**SCOPUS)**

(iii) **Aqilah Awg Abdul Rahman**, Maryati Mohamed (2019). "Checklist of Butterflies (Lepidoptera: Paplionoidea) of Sg. Bantang, Labis Forest Reserve, Johor". IOP Conference Series: Earth and Environmental Science. Vol 269 No. 012042 (**SCOPUS**)

(iv) **Aqilah AA Rahman**, Maryati Mohamed, Lili Tokiman, Mohd Saman Mohd Sanget (2019) "Species Distribution Modeling to Assist Biodiversity and Conservation Management in Malaysia". IOP Conference Series: Earth and Environmental Science. Vol 269. No. 012041 (**SCOPUS)**

(v) Jai Kemalok, Maryati Mohamed, **Aqilah AA Rahman**, Nurul Ashikin Ismail (2019). "Biodiversity across boundary: Ethnoentomology among the Jakun of Kampung Peta, Mersing and the Malay, Chinese and Indian of Kahang, Kluang, Johor". IOP Conference Series: Earth and Environmental Science. Vol. 269. No. 012024 (**SCOPUS)**

(vi) **Aqilah Awg Abdul Rahman**, Maryati Mohamed, Mohd Syahrir Azrin Salleh (2019) "Diversity and Species Composition of Butterflies (Lepidoptera: Papilionoidea) in Taka Melor Amenity Forest, Labis Forest Reserve, Segamat, Johor". Serangga (in press).

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